



“I happens to find internet fun ”

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Interviewed on October 31th, 2006

Born in Berlin, Germany in June 20th, 1933. However, I left Germany when I was 3 years old. Fairly obvious reasons if you're at 3 and half years to 33, so I wouldn't consider myself German, I would consider myself British.

As far as my studies were concerned, I'll say just a little bit more for one particular reason; I actually went to Cambridge, England from 1951 to 54 but the British system was that you took your scholarship exams to University and then I had nine months or a year and nine months to spare, many people went to the army then because we had conscriptions but I actually was at ... California and spent 9 months in UCLA, then came back to finish my mathematics and engineering at Cambridge, but I had a summer job with the army engineers at Los Angeles when back in 52 for another summer job in Los Angeles and so I had a UK-US background already then, and then I got my PhD from Stanford, then I moved back to Europe for 1 year initially; 57 I finished, I stayed as electoral at Stanford until end of 58. Then I went back to Europe initially for 1 year and if you go back for 1 year, you want to go skiing, so I go to Geneva, stayed there 4 years, then I went to General Electrics for 4 years, to catch those connectivity when sitting in Europe, then I went back to Britain in 1967 to University of London. So up to then I had very much a trans Atlantic background and when I left General Electric, I wasn't actually replaced for the next 25 years, so I stayed as a consultant for GE. So I kept having a European-US background; I think it's relevant to the whole of internet activities.

The problem with the NPL activity was it's quite true they had the first switch, but it was one switch in NPL, it was never went through any distance at all; it was never even outside NPL. The first time when they thinks outside NPL was when ...worked with .. network. And if you do things in one organization you don't get very well known.

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Do you remember when you had your first contact with a computer?

No, I don't quite know when I do, but I don't remember what's a computer. When I first went to UCLA, I saw a one hundred meters long mechanical differential analyzer in UCLA and I also saw the SWAC, the South West Automatic Computer, which is at UCLA, I only saw that one at a distance. There were 2 computers built at roughly the same time, SEAC the South Eastern Automatic Computer and the South Western Automatic Computer and it was SWAC which was at the UCLA.

So I saw that but the first one and when I got back to England, I also saw the EDSAC, which was a Cambridge computer. That was a powerful, real computer at that time, then I went to Stanford and that was the first computer I used and that had, I think it was 19 words of storage, that was the 605, IBM 605. And that was the most powerful computer at Stanford in 1954, so that was the first one I used.

What was your first contact/experience with Internet or ARPANET?

Sorry to be long in answering these things but I don't quite know how to describe my first contact. In 1965 or 66, I was visiting UCLA and first of all there was a graduate student sitting up on the roof there, somebody called Vint Cerf. There was an open space on the roof there, it was a flat roof and Jerry described to me the network they were building. And the network at that stage, UCLA had 3 6091, one was in Electrical Engineering, one was with Data Processing Center and one was with medical school. Those 3 were going to be connected together with IBM 360-40 Princeton and that was going to be a network. And that was actually the first network I had seen and it actually spark of the idea of the ARPANET from some sense, because it is for the first time you put a front end machine behind hosts. The next thing, I was following what was happening, and between 19.. I used to go every year to UCLA so I suddenly saw the beginning of the ARPANET, I kept bothering a gentleman by the name of Bob Kahn at BBN, who was working at BBN, kept asking him about modems and how unconnects things are and so on. He couldn't actually believe anything would happen out of it, I was very surprised when at the end it turned out yes, he had by that time left BBN and gone to DARPA and we've arranged at that time. Bob Kahn was actually the designer, the system designer of much of the ARPANET system. The actual building of the IMPs and the SIMPs was of course Dave ...and Frank Heart and various people, and then you know the rest from histories, so I don't need to tell you history. But actually already, in October 2002, when there was that famous conference we know all about, I was talking about the European network situation so it has been deliberately then, complimentary to what was going on in the states,



and that when I suggested to Larry Roberts that we would do something different from anybody else, we would connect computers remotely, which wasn't happening in the ARPANET because all I have was small computers the PDP 9 and I was gonna connect in the ATLAS computer in University of London computing center and the 360/75 at that stage, which was some 70 miles away, and I was gonna connect them and looking one way exactly like ARPA computers, with all the right protocols, and the other way exactly like an IBM front end, an IBM terminal or CDC terminal, that was new to them at the time and if you look at the early maps somewhere around October or November 1973, you will see the ARPANET terminates at UCL on my PDP9 but the hosts are called the ATLAS computer center and the... and later we added also the computer aided design center. So all those three were remote from me but from the US site, they look as if they were ordinary hosts. We used the IBM terminal protocols and in fact as early as October 1973, we've done it already; I gave a talk saying that they rather find that machine on the ARPANET. Somebody came up to me from their system staff afterwards and said "that was a very good talk you gave, however of course, it wasn't true, because we can't tell because we've never seen any sign of being on the ARPANET" I said "that's exactly right, all you see is something that looks like an IBM terminal, which is attached to you, but the other way around, it's got the whole ARPANET around it". They were rather worried about that. That was part of my original proposal in 1971. It took about two years to get the whole thing agreed, I was trying to get some funding, which I never really get and it was nearly ruined at the beginning because Larry offered me a terminal IMP and I put that into a proposal to the Science Research Council, they didn't believe me and the chairman of the Science Research Council wrote to the director of DARPA, requesting confirmation; the director of DARPA has heard nothing about this at all and so he asked Larry Roberts what's all this about, Larry didn't like it coming from the director of DARPA, he was going to do something as surprising as exporting the ARPA network to Europe but then I got to know Steve Lukasic who was in Director of DARPA and he was alright. I think Steve Lukasic was there from 71 to 75, then he went to Xerox and he still works with the government. I was writing the proposal to a small, something like International Science Foundation, pretty far down, but it was surprisingly enough that it went all the way up to the director, equivalent to the National Science Foundation, who then wrote to the director of ARPA for confirmations. At this stage I was also trying to get approval from the department of trade and industry .. and so I wrote to ... who I knew very well and waiting reply for 8 months and when they finally replied, they said they are looking at it very carefully. I was only asking for 20 or 30 thousand pounds I think and they decided that it is much worthwhile to spend 2 weeks on a visit to the ARPANET in the US than to do it ourselves. I am not sure if this is answering your first contact question. I didn't get approved at all, there was no objections from Steve Lukasic and I got 5000 pounds



from Dawn Davies. That was the most Dawn Davies was allowed to do from his own funds and it arrived so I could get started but then my computer arrives and between 1971 when the whole thing had started to be negotiated and 73 when the computer arrives, the TIP arrives, its value was somewhere around 50.000 dollars or something like that and that was the value declared but between 71 and 73 the British have introduced something called value added tax and that was 10 percent roughly of the value or something. So, when this TIP arrived, I've got a bill at the same time for 5000 pounds in order to import the TIP, well that was my tutelage money. So what I did was I under protest said I would appeal but on the mean time I should have it. So I appealed and I appealed for about a year and half and that was then turned down by the treasury and I was told that it was a political issue, couldn't do anything about it. So I then wrote to the treasury and said "alright, I would export this TIP" and then I would re import it under the exchange forces agreement pact from the US to UK. They didn't like the sound of this, by this time I already had contracts from 6 ministries. I was then called in to a very high level of the treasury and said "what you're doing is of no interest to the department of health?" "No sir, although I had a contract from them" "It is of no interest to the British Library?" "No, although I had a contract from them" "No interest to department of education and science?" "No, and they went on to the ministry of defense and so on" then they said "well, in that case, we hereby give you permission, since it is of no interest to any of British ministries and only to United States, you have permission to import this and any subsequent equipments free of tax and duties". For the next 10 years, this small research group was on the end of that time running a complete national service with computers in the Ministry of Defense, computers in ... and so on, countless other places and every now and then people would look and say "why is this research group running an international service?" and I would say "I have no interest in running the international service, just take it off any time. But, you've got to pay all the taxes of all the equipments I have imported" Of course within a year or so after we started we have SAT Net, so I had some more computers for SAT Net, we put on the defense research laboratories so they had more equipments, so there's a lot of equipments there by that time. SAT Net has already consult about it in 1972. Bob Kahn actually started SAT Net more or less in 1973 to give a contract to BBN but it couldn't happen until first of all the Goon Hilly and Tunnel in Norway has been taking care of properly and then it has to involve some offices, so he was discussing with three other countries, Germany, Italy and Canada. German and Italy was no particular problem; they happened but they never did anything because they never had the infrastructure and there were too many problems with what they are allowed to do. Norway never went very far for the same sort of reasons and Canada never got started for a very interesting reason. In Canada, it was Bell Norton who was interested but Bell Norton was responsible for meetings with USA. The



satellite were under, whatever it was, the agency part of UQC or something like that and they were not going to give up their rights to satellite but they had no rights to connect to USA and therefore since those two couldn't agree, Canada could never join. But Comsat was, so we had them, and also some smaller stations at the time. About that time, first of all, the British has already had a centralized research network based on its large 360, by that time 360/95 or 361/95 or something like that, and they had a centralized IBM network. At the same time there were two other centralized network, one was based on CDC of London and the other was ATLAS at computer design center in Cambridge. Then there was also a small network based on a machine in Column, which is the ... I connect all these things on; the CDC one didn't work very well because they had the wrong sort of protocols, we couldn't do anything very interactive but the others were all on for quite a while and in the meantime the networks around them grew and as the networks around them grew, I had to change what we were doing to make it still stay transparent to the US. So just to give a simple example, the DNS came in a few years later, you remember? And the Americans decided the way to do it to say curstine .cs .ucl .ac. Uk. The British always know better, they decided to do it curstine@uk.ac.cs.ucl . So I tried to persuade the British to change, they said "what right has a small research group to change what we do nationally?" so I tried to get ARPA to change "what right have you small foreign research group to change what we do in the United States?" so I therefore had to look at every message, at everything that came through, and work out which way around should it be. Sometime people send messages saying it should be the other way around and that worked very well until 1986 or 87 and then there was a disaster. Chekoslovakia joined the internet. Chekoslovakia has the country code of .cs and when we got a .cs, I couldn't do it anymore, there was no way you could anymore guess which way route it should be. But among other things that were happening is that the DNS in the US, there was something called the network resource system, these are completely different. So I had to update both sets of table every night so it will keep compatibility. Now the impact of that was the British could do what they like and still apparently be on the internet and that's what happened. So it's a rather long process. Finally they changed it in about 1991 or 92, maybe 90, I don't remember. Of course, we had other problems earlier and that was when John Postel was very annoyed with me because the British department of trade in the late 1920's was started talking about car registration and they decided that the British country code was .UB . When I said we were the first domain name outside the US and I had to choose nothing better and chose .UK because that was Britain and Northern Ireland, so I just chose .UK. Around 1986 John was trying to put some order into things and said "Peter, you've got to choose, you can't have two and UB is the proper one, so you've got to choose whether you would use UB or UK. There was a 4 or 5 years period in which we were discussing backward and



forward, the British rejected on principle to being dictated to by the Americans on this, you can imagine all the rest. I at one stage guaranteed to John that within one week of his moving all of the United States onto .US , I would move all of Britain onto .UK but he didn't think this was very funny, perhaps that should be one of my anecdotes. It was even worse; the British, one of them even wanted to have .UKUS to show that one was using the ARPA, the internet protocols and then .GB for the one that used the OSI protocols. That was one of the proposals, I refused that one; I said that was just not the way things are supposed to be done. The other thing where we were first, we were easily the first to use the internet protocols for service; we did the first experiment between Vint at Stanford, Thomas at BBN and ... but my PDP9 which I bought in 1968 were getting rather longer tubes in 1969 and I have to get rid of them; there's no point in putting in NCP again so I started putting in the internet protocols and started running services with them. After 12 years it is probably is a long time for a communication computer with at most 32thousand words which has to do all these works about changing protocols, changing domain. Anyway, so we tried to go into service somewhere around 1981, well before the switchover and we complaint because it was just not ready for service but we had to run a national service on it and is within when they were started on the service, the US started to understand why we are complaining.

So UK was the first domain name; I knew nothing about GB until 3 or 4 years later. It may still exists, I am not sure. MOD decided to use; one of the whole secrets to the thing working was that I said forgot the governing the committee on the budget; The governing committee had someone from the British post office telecomm, it has somebody from the academic side, different people, different times, ... Around about 1974 I wrote to ministry of defense because this whole thing might have been collapsing and they sent the chief of guided missile to talk to me and they decided to give me a contract and various people for instance John Taylor was the first person on my governing committee for the ministry of defense; he later became the director for research council. And there's always somebody from defense and they took a guess around about 1984/5 when this first question of GB came out, that the GB would be the one that wins, not UK, so he moved some of the ministry defense people on to GB but he couldn't move it back so he got froze for while. Maybe it is still over there because they still run somethings in the defense research establishment, we still run some of their web sites for them.

Measuring is on the list. First of all, the whole principle of when could one and could one not have this major difference between the two sites, so for instance, file transfer in the ARPANET was interactive; in the British system, so called colored books, it was a batch link; how do you give reasonable responses when you are trying to go between such things; we were very deeply involved in all the British systems which all based on what the telcos were doing at the time. XXX,all



names that means nothing to you anymore. But the so called colored books, we obviously participated in the formulation of those, particularly grey book on the mail. It was not so much commission, it was before ... project but it was a European project, yes, and a British one. The British really pushed the Colored Books themselves. So we had to be completely colored book one way and then completely ARPANET the other way. So what you could do and you couldn't do on that was already important. The other think is we were heavily involved in SAT net and some of the voice activities at the time and we, actually we did some measurement because around about 76-77 the British started putting in their own packet switch service. First of all, EPSS Experimental Packet Switch Service, then PSS Packet Switch Service and the International Packet Switch Service and we're always tried to be very good British Citizens as well as very good European and also US citizens, so we were part of the SAT net experiments, but then somewhere around 78/79, SAT net stopped being an experiment and the Germans, Norwegians and Italians, stopped participating; we ran SAT net as a service for the next 6 years and what we actually did was we ran SAT net for some of our traffic and the International Packet Switch Service, IPSS is a X25 line, unto other lines. We did some measurements on that for British Telecomm and we also had traffic going one way or the other and if I may get to my second anecdote, around about, I had told you that I had my governing committee and they insisted that I put access control and accounting it because they were worried that one part of such council will get paid too little compared to another part, so I had to do very careful accounting and because I have been given a free line one way to do some measurements for them; 40 kbits line was a lot for 1979/80; 48000 bps; that was the analog version of the 64 kbits line, so I had 48 and 9.6 one way, the x25 and then SAT net the other way, which was 64 and I could used them both ways and I had access control and accounting on but I didn't particularly bother about it in the direction from the US to the UK and I put all the traffic one way so I didn't end up paying anything or paid the minimum and I put access control but I didn't have to pay. Then the governing committee, ... the person post office said "look, he must have access control both ways" so I put access control on principle and send out a notice to everybody, we had automatic log already and I sent out a message to everybody who have passed through my system in the previous 3 months or 6 months or something saying that in 2 months time or 3 months time we will apply access control; if you haven't registered and haven't got the right passed with whatever you are doing at the time, then your traffic would be blocked. And if I may use an .. expression, that wind shifted the fan; I suddenly got a hate mail I have never had before; also it's for about 5000 people; nobody had realized that the internet had actually happened, that people were going one way through UNIX mail, through BIT NET, through any number of different ways and then automatically, because that's the way the DNS works, were coming back through the cheapest, the



quickest, the best route; through me. And so they say "what right you have to block my mail?" because they had no idea they were using my system, it was completely automatic that direction. One suddenly realized that nobody had the slightest idea what the routing topology was at that stage; we had no idea but nor did anybody else; nobody had the slightest idea; we knew who were going through, because we had weeks of logs, we could just look at them, there's no reason to look at them. Remember that we were running a complete national service at any case. But this is in fact even more than national service because by that time there was also European connections directly and nobody had any idea anymore who was going through what and they didn't even know they used emails; everybody thought they were living in a closed world, but they weren't. And by the way, that is one place where I must take exception with one thing you said in your talk today. You talked about switches and then said, which we now call routers. But of course, they are very different and the point was, we have proper gateways and that make a completely different communication system other side of gateways and that's what happened, that make a completely different. In fact the reason that it was put originally I remember completely. The reason it was put initially was because although there were three different networks and you're right, packet radio, packet satellite and ARPANET, whenever one wanted to do any change in any type, and this is in 73/74, the only people that will do the change because they were running the old switches was BBN and every time one want to do it, one was told that there's a delay and costs quite a lot to do it; Bob Kahn was very unhappy about it and the original reason that gateways were put in was in order to have key separation between the network part which ends at Frank Heart and the rest, so release one from the tube at BBN. But another division of BBN got the contract to do gateways, so the monopoly stays but the fact that it was a different group doing the gateway that make huge different and of course then parallel, Dave Mills is doing it ... with comsat at the time. Fairly earlier on and remember at these days international communications are not allowed, you weren't allowed to have switch telephones on other types and I remember early on, something like in 75, the British Network I've talked about already had its leased lines including center. I got a request from CERN, could we link to the ARPANET from CERN? So I had to asked my governing committee and my governing committee, the post office man, said no. We then said we do not allow this but please tell us what you are doing to prevent this. The problem was that I was allowing anybody on that research network, it was a centralized research network. I was letting everybody out except CERN to go through, how did I stop CERN? So he gathers it might be possible without that knowledge: what am I going to do to prevent it? So I wrote back, the following of the five methods they can get through with, I can prevent. The sixth methods that I can't prevent is the following; Shall I put up a notice at CERN, saying you musn't do XYZ, ABC because otherwise it would illegally



go through to the US? They decided I shouldn't put up that notice. All of these took a lot of work, it's not for nothing because we started thinking very early on about access control and security and that was important. We got to be very heavily involved on that later of course.

In your opinion, what are the key characteristics of Internet?

Well, I think one of the most important one is that you have a particular level at which interconnections is possible and that isolate things both above and below that particular level. That means you can have different network technologies below that level and different application technologies above that level. The fact that it is a value universal one, gave one a lot of freedom in what one connects with and how one connects with. The problem is it isn't completely optimal, so as long as I remember, there has been attempts to break through the rigid levels and optimize things below or above and of course if one does, one is going to break; this universality, but it become more efficient, and we've had this dicotomy for as long as I remember; it is still there. People are putting QOS, signalling what you need for QOS, etc. That's always been; the key problem is that you had the capability of having the insulation and then you fill either above or below with various mechanism for guaranteeing quality of service or security or anything else. It is not a deadlock, I mean it works fairly well, it works better now than it used to; the reason that it works better than it used to is because we can now over engineer on bandwidth. It is interesting actually; one of my main project now is concerned in introducing the internet satellite base in centrally focused; there we have limited bandwidth; 30 Mbits for the whole 2 regions; it should go up to 50 very shortly but we want Voice over IP and conference; one can do that by putting in the right quality of service in the routers, and that's what we do, you have to register, we have time terminals, who should get priority and then those get priority and ... are able to do that. On the other hand, that's very heavy work on the routers; So what I have at the Vsat network based on daisian.. the GSR doing much of the quality of service activities because it has to do on the provisional basis and its really big. And by the way the interesting part also, is of the technologies once using it back to the SAT net.

You do touch it of course, I am a great believer in IPV6, which of course is touching it and by the way I think that will certainly happen and the main reason that it will happen is because so many of the newer protocols are being aligned for the IPV6 so sooner or later it will have to happen.

The other character is the myth scalability; I mean the fact it survived at all from the original experiments in 1975 to what happened to it in 2006, is incredible. We always thought about doing one or two conversations over this thing but to actually have the level of real time traffic we now have was never imagined at all. Then of



course the next is the various application specific protocols, in particular of course, the web. I found it easy to adjust to the things that existed underneath, one thing which still needs working through is the fact that there are a number of different ways of doing security and that causes real problems.. And I don't see any sign of that being resolved. There are too many vested interests. VPN means you have one form of control by one set organization; you can mandate IPSEC but you're not gonna have that done on the mobile side because they want to have security based on what they control; you have today from HP, where you could have some cards in the laptops, that's the security which the mobile telephone world would like better and the fact that you have so many different types is very unfortunate and yet they are all essentials. Sorry, it's essential to have it somehow.

What do you consider the most important milestones in the development of the network?

I think the first really important one was the concept by Bob in 1974 that you want to have different networks, a completely different network; having at some levels in protocol, structure and we realized that in 1978 Vint and I write the only joint paper we ever written together, specifically analyzing gateways and different types of .. which could exists. This was probably October 78 or something like that; he was my project officer, you see I have always had on the one side these people I mentioned in UK, then a distinguished set of project officers from DARPA because I had DARPA contracts from 1973 to 2003/4. I think by the time I stop ... Douglas continuously run of DARPA contracts and the list of people who were my project officers is a very distinct list; It was originally Larry Roberts, later it was Bob Kahn, it was Vint Cerf, then it was Paul Mackepatrice, then it was Nicson John, Dyke Moon, Hillary Oman, all the people you know of one way or the other; I think Steve Crocker at one stage, they all have been my project officers and we were always trying to put a slightly different flavor on things, so Vint ... programs at DARPA, we would put, we did our application level while anybody else did the network level, just sort of do something different. I once gotten a word from I've forgotten who, at DARPA for biggest bang for the buck; the idea being our pro contracts was so very small, quite off the standards, but we gave reasonable value for the small contracts we had. So I think clearly, the concept of connecting networks was the first really important.

The next really important one was actually putting them to practice and that came in several ways; on the one side, the introduction of TCP/IP altogether and second of all, the growth in access networks, separate from the backbone networks, but still use similar protocol structures, very easily connected. Clearly the DNS, which was not off the TCP/IP was a huge... And then of course, the next biggest milestone was the winning of the protocol wars, which was an



absolute and complete victory, around about 91/92. The milestone that I am still waiting for is when there's a real acceptance in the US that IPV6 is a good idea. So far, all of the manufacturers are providing it but there is a very big sign of data. The real people pushing for it are the Chinese and the Japanese. In fact the main reason for Cisco went into it was because NTT request for tender, which requested that IPV6 be available and Cisco couldn't respond and Cisco doesn't like not being able to respond so immediately they put in an IPV6 program and virtually after the European pushed, all the American companies have implemented IPV6 on their products. So they went up ahead. But I mean it's completely standard on Microsoft, it's completely standard on your stack on Cisco, no difficulty at all. It's a chicken and egg, there's no immediate shortage of address in the United States. As soon as the US cross over, other countries will cross over too and there's much greater shortage in Japan and China and in addition, they want to be different, they want to be in advance and they will be. They get much more experience of the applications, right? The only thing which has changed that is the DOD announcement, I don't take the announcement very seriously but it did mean that there was some sizable projects, ... in particular, which adopted, which extra work through problems with IPV6 deployment; so these were done in lots of serious work; something like Jim .. very good; I didn't get the impression... today as the slightest idea how advance HP is in .. about IPV6. Jim was at HP, Jim bound to HP but he is in charge of IPV6 at the very control room.

How did you contribute to the development of the Internet?

First of all, not only having it international, which was just a quest Larry Roberts gives to me but developing it into a real user community, first of all in Britain. If you compare what happened in UK with what happened in Norway, Italy and Germany, which all had satellite IMPs as well, it didn't developed in any of them and it didn't developed because in none of those three there was a slightest attempt to really bring in a user population and to track whatever was happening in nationally with what was happening in the US. It was being much opportunistic to think you could bring it in a minute and import straight into the European countries; you have to follow what is happening in Europe, track it and make things compatible, and that I think was for a while an exchange novelty, it was not efficient, it was never going to scale, where the internet wanted to scale, but at least it made it possible to get a lot of experience of it and build up so when, we of course move over to TCP/IP, so we were at decision to move over to the proper internet as it is today.

I think the other thing that is very important about it is it kept the US side much more internationally minded. I don't know if you are aware, that in 1981 Vint started two different activities; the international collaboration board for the defense and international activity board. I ran the ICB from 93 to about 2003. It was small, it only had some 6 or



8 defense department. In Canada, the UK, Germany, the Netherlands, sometimes Norway, NATO and Denmark; that was small but at least it kept the international presence going for these things. I killed it when DARPA said the thing could no longer attend if it was outside North America. I felt that it was no longer International enough, so there's no point in continuing it. It's not so much of cutting expenses, it's much more the US become more, that part of the US suddenly become much more introverted. I think the US has always been strong but sometimes it is being more international minded than other times and I think it is not its most international commitment, the moment it would like people to approve its policies, to collaborate with its policies, it would necessarily do other things.

There are other things; we were very heavily involved in multimedia for a long time, and I think it was more linking some of these things, originally it was UK-US but later it became very much more European-US as well, so for instance I ran a whole series of multimedia European projects which had me collaborate with the US or something like that for quite a while. And I think in the project we did, we always did something a little bit different in attitude but not me in the major way, but we kept international presence for these things.

I would say developing it, bringing it was easy but to develop a user population is much more difficult. In fact, it must have been; the Norwegian one must have been days before ours. The reason it must, although the original aim was to go by satellite to Guinea by leased line to Norway, by the time it happen, which is two years later, there was both the Tanama station and Guinea stations and I believed the first one landed in. The IMPs came on the same time, which one is connected first, it was days, I don't remember which one first. I think initially one was by satellite and I think initially ours must have been first, I think it went initially first to good hilly and then to.. I don't remember whether at that time it went first to good hilly and then to oslo or first to duam tanem in Sweden and then to UK but initially there was a leased line 9.6 Kbits from the UK to Norway. The reason for this is that there was something called the nuclear monitoring research organization, DARPA office. That was doing nuclear monitoring of its presence and that had 3 largeries, one in Alaska, one in Montana and one in Norway. And that had a 2.4 Kbit link, the Norwegian one, to Washington. Larry's first idea was first of all you want to put the array to the ARPANET, second is that do analysis and increase the line speed to 64 from 9.6, you could do it. That's how the whole thing started as far as that is concerned. They had the line already except for the fact that they also need to break the line internationally which wasn't allowed of course, and I had to find out about it. At those days, the idea of an academic asking the post office about the defense line, which is international and we had very strange things in the first few years of that. I don't remember the situation in July 1973. Initially it went from Washington to goon hilly and then to London; in London it was less an exchange and there I went by underwater cable to Norway. I had a feeling that somewhere



around 1972 or early 1973, the main line, the one going to Nassau actually went to Tanama and then straight to Nassau so I believe that the line went from Norway to London when the satellite link went to Norway, I believe. That change, by earlier 1975 because that's when the SAT net project probably started and then we had satellite IMPs, both in Gøteborg and in Tanama and in Germany and in ...

The US did it because it didn't need very much money. It was always fairly easy to put in an extra IMP; that wasn't very difficult, I mean they are putting already 40 or 50 and putting one next to one in Norway wasn't very difficult. The contract without ... They could see already then, that they are going to need to expand that; I remember being in the office of the Director of Nuclear monitoring research office, caught him talking to one of his friends in France, in the same department and he was complaining "every time I put in a seismic radio, we have very small ones and we have big ones, they gonna have a revolution in the place" and they already had quite a few in place, small ones, in Africa and Asia. Fairly early on, in 1974 or 5, I have a link straight to the intelligence authority. On the peaceful side, I meet with.. which was doing the monitoring of explosions, but that's the peaceful side. I have that for about 20 years.

Who are some key people in the development of Internet, leaders or trendsetters?

First of all, quite clearly Bob Kahn and clearly Vint. John Postel from the really keeping things going throughout in the very conscientious fashion. I think one of those who is underrated is Dave Mills. I think he is under rated; first of all, he was the first person who break the monopoly of the gateways; the other side gateway that he put together was the fuzzball, where he is very good and then we have the impact that we at one stage had 50 nodes all doing different things, a whole concept. I think that a person that belong to government but did a lot for our side of thing is Peter Higginson; he did all the software. I think he must have left around 76/77. Who else I want to mentioned, particularly from the British side. From the mail side, Steve Kille; I would say those the most important. I would say that Garry ... and Bob ... is important from the support point of view, .. Davies of course but he is more from bureaucratic point of view, from the internet point of view. Donalds was with NPL networks but the problem with NPL network was it was an in house network only; they was never able to get any funding at all for going outside NPL. EPSS was different; The British post office decided that they would put in a packet switch service; initially internationally : IPSS but also nationally. In order to do that, they would first put in an experimental and the experimental packet switch service is the EPSS. I was under the strict instruction and I suspect Donalds was as well, that we had to provide access facilities to our networks through this and I did actually provide EPSS access through our PDP 9. The PDP 9 was running all protocols and nothing else, that all they were there for. I



had 3 of them and towards the end of the time I need to have an extra one in case one of them broke down. And so the EPSS had very little to do with Donalds. What Donalds is in particular concern with, is something called the EIN the European Informatics Network. That he start in the one putting things in from NPL, particularly France, the Cylcade network and it also involved ISPRa but that was not with NPL; NPL network was never outside NPL. We also of course used International package switch service, that said for one or other things but Donalds was never able to do that; he was never able to get out and that was very sad.

Paul Mockepeters.

Another one extremely important but you don't hear much in these days, on the radio side is Jim Matthis, also on the routing side. Dave Waltz was always very important. I feel Frank Heart did a very good job on the switch part but it was not in very strategic portion of it, I don't think he was involved in the internet sides of thing at all, as far as I know. The IMP was a packet switch, that's exactly what it was. Somebody else who again one forgotten about but probably did more to revolutionize things than anybody else is Len ... they never mentioned him to you? And by the way, we have the first Cisco router in Europe, then drop it off and then show it to Len from Stanton and Len was showing it in Paris and drop it off in my place. But Len, again, made successful of this, by the time there was no... who was.. but they died whereas Len survive and of course, Bob Met Calfe, because again, the ethernet was absolutely vital. One who could have a strong impact but in the end didn't was Morris Wilson. He didn't because he came between could have been a good access technology, in fact it was the token ring. But Morris was on principle didn't like to have standardization so it never took off, so it wasn't a good access technology anymore. One of the really far thinking one is clearly Lick Lyder; I don't think he had much to do with the internet itself but he was thinking broadly around this you can't do anything without Berners Lee of course, but that's obvious. I think the first person who probably put more order onto the security side than anybody is Steve Kin. Steve is really a very intelligence person and he's followed this security from the beginning. Len started a lot on making measurements respectable but actually the person who I really liked from the measurement side is the guy in San Diego, ... she is still there, Kimberly is her first name I think. She is the one who has done more than anybody else in measurements lately and she ran a part measurement center at UCSD but she is not an old timer.

Two anecdotal situations



What do you think about the future of Internet?

The first think, I would be very interesting in watching its impact on areas it hasn't gone to before, where the impact is huge. I get amused to some sense that history is repeating itself. The problems we had in the 70's and early 80's in getting things accepted in 1 or 2 countries in Western Europe then have to be played through again in the late 80's and 90's in the rest of Europe and Japan and some other countries and now having to be played through yet again in every other countries I deal with. Problems are that we need to support these things, particularly research communities; we just done a short report on the status of funding and services in the newly independent states in Central Asia and the Caucasus and virtually none of them have state funding for their research networks. There was a time... No, we are putting in money from NATO and UNDP and a few other people but there are no national funding yet. The still don't realize its importance; the same happens of course in Africa; European commission is trying to do something about this but they are putting very harsh European prospective without fully realizing how difficult it is to be for somebody else's country to adjust and remember when I talked to them nearly 10 years earlier, I had what is particularly amusing. I think that it would, even when IPV6 does come in properly it will have an immense impact; sooner or later it will do something even about the address shortage going on in several places; that will have a major impact on services you have to use. Speed, it is obvious that everything is going up. I see very clearly that the battle to have all real time services and go over IP have been pretty well won. What impact it's gonna have on the whole communication perspective of companies, is not clear.

There's more than that, the battle of circuit switch telephone exchanges to; well I think it is more or less over, I think it is more or less work. I think for the long term its over but the impact that it have on the finances of the whole communication industry is not over and that should be a very difficult interest in one which to watch. But, it all very well for Skype to say that this thing is free but that implied that there's new infrastructure and how is that infrastructure is going to be maintained under this, is not clear. The whole question of convergence and whether or not the mobile industry will change is still isn't clear. There's a lot of re-arrangement so things happens in that area but it's all related to the internet.

Except for the fact that you have scheme regulators now in so many countries, so it is not clear. I asked him afterwards and how much will it cost and he said the .. has decided on its rate and it has one rate, which I forgotten what, not particularly expensive for the basic access but then you get I think it was a fixed amount a month and then you got I think, I've forgotten, 250 mbytes included after, that's expensive, and roaming charges come on top of that. So if you are



going to do this internationally, you have a huge bill to pay. So, it's meaningless to say that so and so will happen if you don't have tarras associated with it.

I remember once giving a lecture in Russia and had some.. responses; I spent 6 months in Russia so I speak some Russian and the translator translated when I said something about tarras, to good cost, so I said, no no, I repeated and I forgot what the right word was because it means completely different.

Do you see any technological trends?

Well, obviously fiber yes, fast switches yes, I think satellite will continue in the parts of the world I deal with; it's quite clear that fiber will take over in principal places but if you look at geography or topography of central asia, there's no chance that fiber would go through all the places. So the strategy we have, is we are putting in satellite now, we expect to be able to put in fiber to the main capitals within the next 2 or 3 years, and then we'll move the earth stations more to the remote regions of the countries; I think that's what is gonna happens. It's a NATO, it's my job to do a little bit of deal making so NATO is paying for the main part of communications, I have persuaded the European commission to pay for the management of a NATO project, which I think the first time it ever happened. I persuaded CISCO to donate a local area network in every country, nine countries to go between the earth station and the national research network and then we got a little bit of money from ISOC and a little bit of money from various others. But we are going to get some probably from the Agakhan because of the university in Central Asia, in the mountains, the world bank is interested in doing video conferencing in some of the remote places, we put a video conferencing system in each of the countries and we are now working with the desktop conferencing. These are the things that we used to do 20 years earlier.

ADDITIONAL READING

PAPERS & BOOKS MENTIONED / RECOMMENDED